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Color Infrared Aerial Photography for Root Disease Detection

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COVER--Root disease center as it looks from the ground. Note downed logs, dead trees with tops broken off, and lighter colored brush in the center and thin crowned trees on margin.

COLOR INFRARED AERIAL PHOTOGRAPHY FOR ROOT DISEASE DETECTION IN THE NORTHERN REGION

by

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ABSTRACT

"Holes" with dead, dying, and downed trees in the forest canopy could be reliably identified on 9- by 9-inch Kodak Ektachrome Infrared Aero film 2443 as root disease centers. Film scales larger than 1:4000 were best for detection of these "holes."

Most commonly occurring causal organisms in root diseased trees were *Armillaria mellea* and *Poria weirii*. Although trees in latter stages of decline could be visually identified from photographs, red filter optical density measurements were extremely variable and inconclusive.

INTRODUCTION

Aerial photography has been a valuable tool in detecting infection centers and tree mortality caused by root decaying pathogens. In eastern pine plantations workers have found that trees killed by *Fomes annosus* (Fr.) Cke. could be identified on color infrared photographs (Murtha and Kippen 1969; Hadfield 1970; Hanson and Lautz 1971). Furthermore, Murtha and Kippen (1969) and Murtha and Hamilton (1969) indicate that detection of root infected trees in previsual stages of infection can also be accomplished.

Johnson and Wear (1972) report that the ability to detect root disease centers caused by *Poria weirii* (Murr.) Murr. in natural stands in Washington varied considerably with the area, film, and scale. In some areas success was not good. Small-scale black and white aerial photography was best in their tests.

In the Northern Region, observers for aerial detection surveys have noted that areas of extremely reduced basal area appearing as "holes" in the forest canopy and possibly caused by root pathogens were evident. Examination of these areas and subsequent aerial observation by the author of areas known to be infected with root disease showed that these root disease centers could be detected from the air. Centers varied from a few trees to several acres in size.

The next step was to determine the usefulness of aerial photography to detect and document root disease centers. In 1972, preliminary evaluations of aerial photography for the detection of root disease centers were made. The primary objectives of these evaluations were:

1. To test previsual detection techniques for root diseases

2. To determine whether aerial photography could be used to identify root disease areas, and if so, what scales would do the best job, and

3. To determine whether aerial photography could be used in root disease impact and distribution surveys.

MATERIALS AND METHODS

Portions of each of two subcompartments, consisting mainly of medium to well stocked Douglas-fir pole to sawlog stands (numbers 3178 and 3654) on the Coeur d'Alene National Forest which had been recently inventoried and were known to contain large areas of conifers infected with root pathogens, were photographed using 9- by 9-inch format Kodak Ektachrome Infrared Aero film type 2443. Infrared film was used primarily to meet objective number 1. Areas were photographed at three different scales: 1:1200, 1:4000, and 1:8000, in order to determine which scale(s) would be best.

The 1:1200 photography required for previsual detection techniques (personal communication with Dr. P. A. Murtha) necessitated the use of a camera with a 12-inch focal length lens system. John Wear, Region 6 Remote Sensing Specialist, who had this equipment, photographed the areas. The camera used was a KA-2 camera equipped with a rapid cycling film magazine using 9-inch film, and a 12-inch lens with a Wratten 12 filter.

Once developed, the photographs were scanned with an Old Delft stereoscope, and known and suspect root disease centers were delineated. Openings in the forest canopy with "root thrown" (i.e., windthrown trees with several decayed roots) in the center and/or bordered by trees, primarily Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) and/or grand fir (*Abies grandis* Lindl.) in various stages of decline, were used as criteria for delineation of root disease centers.

Photos with the known and suspect areas delineated on them were then taken to the field for ground checking. This involved chopping into roots or butts of trees on delineated areas and examining for signs and symptoms of root decay.

To evaluate the effectiveness of red filter optical density measurements in detecting trees in early (previsual) stages of infection by root disease organisms, density of images of trees on and adjacent to margins of root disease centers was measured. Trees were then ground checked in order to correlate tree image densities with ground truth data.

RESULTS

General areas with large amounts of mortality and larger root disease centers (larger than one-fifth acre in size) could be identified (fig. 1) on the 1:8000 photographs, but in order to delineate and more accurately and easily identify centers, the larger scales (1:4000 and 1:1200) were better, with the 1:1200 scale being the best. This was due to the ability to detect "root thrown" trees and more accurately identify species of trees in the area (fig. 2). Small root disease centers with only two or three dead trees could also be delineated more easily on the larger scale photographs.

Trees on all areas delineated on the photographs were found to contain one or more root pathogens, primarily *Poria weirii* and *Armillaria mellea* (Vahl ex Fr.) Kumm. In addition, numerous other small root disease centers containing two or three dead trees, which had not been delineated on the photographs, were found to have root-diseased trees. It appears that photographs were too conservatively evaluated and that at least in certain areas (i.e., the study areas) dead trees are nearly always indicators of the presence of root disease.

It was obvious from the 1:1200 photographs that images of living trees around margins of root disease centers varied in visual density from a very light pink to a dark magenta. Field examination of 20 to 30 trees at each extreme showed that trees with lighter images exhibited signs and/or symptoms of root disease organisms at the root collar or were older than adjacent trees. Trees with the darker images did not exhibit signs or symptoms of root pathogens at the root collar.

Although red filter optical density measurements were taken on trees in each group and compared, results were extremely variable and are inconclusive at this time.

Figure 1.--Large root disease centers appear as "holes" in the forest canopy (groups of centers at arrows).

Figure 2.--Root thrown trees (at arrows) as seen on large-scale photography (larger than 1:4000) help to identify root disease centers.

DISCUSSION AND CONCLUSIONS

Preliminary evaluations have shown that aerial photography using color infrared film was effective in detection of root disease centers in two different study areas on the Coeur d'Alene National Forest. Obvious root disease centers, those with definite margins and trees in various stages of decline and with root thrown trees in the centers, could be interpreted from photographs with nearly 100 percent accuracy at film scales of 1:4000 and 1:1200. Accuracy in identifying root disease mortality involving one to three or four trees in a tight cluster was not as good because definite patterns were not observed. Mortality of this nature could have been caused by blister rust and/or pole blight of western white pine *(Pinus monticola* Dougl.*)*, fir engraver beetle, *Scolytus ventralis* LeConte, in grand fir, and Douglas-fir beetle, *Dendroctonus pseudotsugae* Hopk., on Douglas-fir.

Bark beetles have been associated with root decay organisms (Furniss, et al. 1973; Partridge and Miller 1972; Hertert, et al. 1973), and little western white pine was observed in the area. Therefore one may surmise that the majority of mortality in the study areas was in some way associated with root pathogens. Perhaps stand composition data will be a valuable asset in interpreting photos in future surveys.

Although evaluations were conducted only on areas of known root disease centers and with little variation in stand characteristics, centers containing more than one or two dead trees will undoubtedly be obvious in stands of differing characteristics also. Since the root disease problem at this point appears to be connected with the larger centers, detection of the smaller ones may not be critical, and impact and distribution survey designs utilizing aerial photography should be workable.

In addition to being useful in the detection of root disease areas, periodic aerial photography of root disease areas should help determine mortality rates or rate of spread in these areas.

The use of other types of films for detection of root disease in the Northern Region has not been fully evaluated. It would seem that films showing up mortality the best, eg., color films, would be best in root disease detection. Mortality is very evident on color infrared photographs, but may not show up as well on true color photographs. On the other hand, preliminary work with 35 mm color photographs suggests that the use of color films in the fall after color changes in shrubs have occurred may be very useful in detecting root disease centers. Once centers are found, more intensive examination could be made for mortality around and in them.

Root diseased living trees could be detected visually on the photographs, but all these trees were in the latter stages of decline, probably 1 to 3 years before actual death. Red filter optical density readings, however, were extremely variable and inconclusive. Several reasons for this seem apparent:

1. All age classes of a variety of species of trees were present and infrared reflectance is highly correlated with species and age (Murtha 1969).

2. Images in central portions of photographs were generally less dense than similar images on margins of photographs.

3. Roots could not be fully evaluated as to degree of infection. These factors can be overcome in time.

In summary, preliminary evaluations of the use of aerial photography in the detection of root disease areas have shown:

1. Color infrared film was effective in detection of root disease centers in two study areas.

2. Photograph scales of 1:4000 or larger were best in detection of root disease centers.

3. Aerial photography using color infrared film should be able to be effectively used in root disease impact and distribution surveys.

4. Trees in the latter stages of decline could be reliably identified on the photographs, but more work will be needed to determine the effectiveness of densitometric techniques in identifying root diseased trees.

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